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Original Article

Cadmium and Lead level in *Eichhornia crassipes* from River Nun, Niger Delta, Nigeria

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Abstract

Eichhornia crassipes is an invasive plant with adventitious root system and constitute nuisances in the waterways. In the Niger Delta region of Nigeria, they have remained underutilized. This study assessed the level of cadmium and lead in *Eichhornia crassipes* from River Nun, Niger Delta, Nigeria. The samples were collected from five locations in three batches within six weeks and analyzed using standard analytical methods. Results showed that pH, temperature, cadmium and lead of the water samples ranged from 5.51 – 6.68, 27.60 – 29.57ºC, 0.003 – 0.167mg/l and 0.002 – 0.063 mg/l respectively. While the concentration of cadmium and lead in *Eichhornia crassipes* ranged from 0.022 – 0.045 mg/kg and 1.095 – 2.450 mg/kg respectively. Analysis of variance showed that there significance difference ($P<0.05$) across the three batches the samples were collected. The concentration of lead and cadmium in *Eichhornia crassipes* in relation to the water samples suggests that the plant is aiding the removal of these heavy metals (cadmium and lead) from the water. This study confirms the remediation potentials of *Eichhornia crassipes* in the purification of water.

1. Introduction

Phytoremediation is the use of some plants to purify environments including, soil, water, air contaminated by pollutants such as heavy metals [1,2]. The degradation of the environment by toxic metals is one of the major problems affecting its sustainability, thus affecting agriculture and contributing to bioaccumulation and biomagnifications in the food chain [1]. Al-Ubaidy and Rasheed [3] noted that civilization, industrialization, agriculture, economical and urbanization are the leading cause of environmental pollution especially the aquatic ecosystem. Aquatic environment get contaminated by heavy metals through deposition of wastes, runoff after rainfall and to lesser extent through geological formation. Others means through which heavy metals enter the environment include drilling [4], dredging which could have impacts on sediments, water quality, plankton communities and vegetations [5-15]. Several aquatic plants such as *Typha latifolia, Eichhornia crassipes* have demonstrated potential for the remediation of pollutants related to heavy metals in aquatic ecosystem [1]. Others are water mimosa [16] and *Ceratophyllum demersum* [3]. The removal efficiency by the plant varies in plant species as well as the type of heavy metals.

Some non-essential heavy metals such as lead and cadmium are highly toxic to biota. Typically most heavy metals are difficult to degrade, but it can change its forms [17]. These heavy metals have the potentials to interact with biological systems and they can change their speciation [2]. Typically, cadmium find its way into the environment through anthropogenic activities including mining, industry, and burning coal, leakage of hazardous and household wastes [17]. Like most substances that can aerosolize, cadmium particles can travel in air for long distances before depositing on environment (water or soil) [17]. Lead could also enter the environment through fossil fuels combustion, mining and other manufacturing industries [18] including production of batteries, ceramics [19], tires, lubrication oil [20], paint, leaded gasoline (petrol) [21].

Eichhornia crassipes have been widely used to assess pollution level in aquatic environment with regard to heavy metals such as arsenic, cadmium, lead and mercury [22, 23]. The use of aquatic plants such as *Eichhornia crassipes* to detoxify the aquatic ecosystem could be attributed to high growth rate and biomass yield under conditions of applications. Hence, it can be used as bioindicators. Typically, *Eichhornia crassipes* is a productive free floating macrophytes found in tropical and subtropical regions of the World. *Eichhornia crassipes* have been widely reported as potential livestock feed ingredients [24] including pullet chicks [25], Rohu [26], *Clarias gariepinus* [27, 28], *Cyprinus carpio* [29] goats [30, 31]. The ingestion of toxic metals above tolerable intake level by man could cause health related effects [32]. For instance, lead are known to cause adverse effects in man including central nervous system, kidneys, and bones, while cadmium have effects in the liver and kidneys, central nervous system, immune system, bones [32].

Several methods have been widely reported uptake heavy metals from contaminated water including physical, chemical and biological. The physical and chemical approach of heavy metal removal from water has been broadly acknowledged in literatures [33 – 35]. Typically most physicochemical methods of heavy metal removal from water include chemical precipitation, ion-exchange, adsorption, membrane filtration, coagulation-flocculation, flotation and electrochemical methods [33, 36, 37]. These treatment technologies are mostly expensive and cannot completely remove dissolved metals in water [17]. Therefore, the use of plants for removal of toxic substances has gained attention.

Different part of *Eichhornia crassipes* have been reported for heavy metal uptake. Mohamad and Latif [17] noted that higher concentrations of metals are found in the roots as compared to the shoots. The authors attributed the higher accumulation factor in the root of *Eichhornia crassipes* to their absorption to the surface of root tissue. Due to the fact that a lot of wastes are deposited into the aquatic ecosystem, and *Eichhornia crassipes* are found in enormous in the Amassoma region of River Nun, therefore this study aimed to evaluate the level of lead and cadmium found in *Eichhornia crassipes* in River Nun, Niger Delta, Nigeria.

2. Materials and Methods

2.1 Sample collection

A total of five sampling locations were mapped out along River Nun at Amassoma axis, Bayelsa state, Nigeria. The distance between each sampling location is about 250 meters. Sampling was carried for a period of six weeks in three batches i.e.14 day interval. A total of 45 water samples and *Eichhornia crassipes* each was collected three being for each location across the different batches. A one liter sampling containers was used for collecting water samples meant for lead and cadmium analysis. While the *Eichhornia crassipes* (including the root, stem and leaves) was collected using jute bag. Sampling was carried out between April to June 2013. The samples was carefully labeled at collection location, and transported to Laboratory in an ice box where it was prepared and preserved prior to the analysis.

2.2 Water hyacinth sample preparations

The *Eichhornia crassipes* samples collected were washed with tap water and allowed to drain out. The samples were sun dried before transferring to oven at a temperature of 105ºC. Thereafter, the sample (i.e leaves, stem and roots) was blended together using pestle and mortal and preserved in sterile Ziploc bag prior to heavy metals analysis.

2.3 Physicochemical and heavy metal analysis

The pH and temperature of the water was analyzed in-situ using pH meter (Model: HANNA HI 9820) and dissolved oxygen meter with temperature gauge (Extech 407510A) respectively. The cadmium and lead content of the water and *Eichhornia crassipes* were analyzed using Atomic Absorption Spectrophotometer (AAS) [38].

2.4 Statistical analysis

SPSS software version 16 was used to carry out the statistical analysis. The data were expressed as mean ± standard error. A one-way analysis of variance was carried out at P = 0.05, and Post Hoc was carried out using Tukey HSD.

3. Results and discussion

Table 1 presents the pH, temperature, and heavy metals (cadmium and lead) from water samples and *Eichhornia crassipes* samples from River Nun at Amassoma axis, Nigeria. Temperature ranged from 27.60 – 29.57ºC across all the sampling points in the three batches. There was significant difference (P<0.05) among the different locations across the batches. The variation in the water samples from the sampling locations across the batches could be attributed to the time of the sampling as well as the relative humidity of the day. The temperature is within the range reported in 2007 at Amassoma from the same river (River Nun) by Agedah et al [39].

The pH of the water ranged from 5.51 – 6.68, being significantly different (P<0.05) among the sampling points across the batches. The variation could be attributed to the acidity or alkalinity of the different wastes deposited in the water via runoff and or human depositions. The pH of the water samples in this study is slightly lower (more acidic) than the range reported by Nyananyo et al. [40] in 2005 and Agedah et al. [39] in 2007 from Amassoma axis of the River Nun in 2007, but within the range reported by Ogamba et al [41] in 2014. The slight variation could be associated to level of contaminants and season of the different studies.

The cadmium concentration in the water samples ranged from 0.003 – 0.167mg/l across the three batches. Apart from location 2 in batch A and Location 1 in batch B, there was no significant variation (P>0.05) among the various sampling points in a given batch, but significant variation (P<0.05) exist across the batches. Similarly, the concentration of lead in the water samples ranged from 0.022 – 0.024 mg/l (Batch A), 0.054 – 0.063 mg/l (Batch B) and 0.002 – 0.003 mg/l (Batch C). However, there was no significant variation (P>0.05) among the various sampling points in a given batch. Also significant variation (P<0.05) exist across the batches. The variations in the concentration of the heavy metals under study in the batches could be attributed to differences in amount and type of wastes deposited into the river either as wastes or runoff since the study was carried out in the raining season and flooding do occurs in the region. However, the concentration of the lead and cadmium is comparable to previous study carried out in 2014 at Amassoma axis of river Nun by Ogamba et al. [41].

The concentration of heavy metals i.e. cadmium and lead in the *Eichhornia crassipes* ranged from 0.022 – 0.045 mg/kg and 1.095 – 2.450 mg/kg respectively. There is significant variation (P<0.05) in the sampling points across the various batches. The high concentration of cadmium in the water samples than the *Eichhornia crassipes* in Batch B could be attributed to duration of exposure prior to sampling. Mohamad and Latif [17] reported that the uptake of heavy metals by *Eichhornia crassipes* could be due to exposure duration and concentration. The concentration of lead in the *Eichhornia crassipes* was higher than the water samples. This aggress with the reports by Sjahrul [42] that reported that uptake of heavy metals such as cadmium and lead by water hyacinth increases with increasing concentration of the metals.

Lead concentration in the *Eichhornia crassipes* is higher in locations were the pH is lower (more acidic). Typically, pH of the water plays a significant role in determining the pollution index. The presence of slight acidic in the water generally is an indication that the pollution level is low. Also, the age of the *Eichhornia crassipes* could also play a significant role in the remediation of heavy metals.

Table 1: Level of cadmium and lead in the water and *Eichhornia crassipes* samples from River Nun, Niger Delta, Nigeria

	Station	Water samples				*Eichhornia crassipes*	
		Temperature,ºC	pH	Cadmium, mg/l	Lead, mg/l	Cadmium, mg/kg	Lead, mg/kg
Batch A	1	29.17±0.12de	5.89±0.10ab	0.027±0.003a	0.022±0.001b	0.030±0.004abc	2.450±0.115f
	2	29.47±0.12e	5.82±0.12a	0.033±0.003ab	0.024±0.003b	0.030±0.000abc	1.813±0.088bc
	3	29.40±0.11e	5.91±0.06abc	0.027±0.003a	0.023±0.002b	0.043±0.006bc	2.184±0.009ef
	4	29.37±0.09e	5.91±0.06abc	0.027±0.003a	0.023±0.002b	0.033±0.002abc	2.136±0.006e
	5	29.57±0.09e	5.91±0.01abc	0.023±0.007a	0.023±0.001b	0.030±0.001abc	1.856±0.058bcd
Batch B	1	28.30±0.17abcd	6.19±0.22abcd	0.100±0.000bc	0.054±0.001c	0.026±0.001ab	1.367±0.007a
	2	29.37±0.18e	6.31±0.27abcd	0.133±0.033c	0.058±0.003c	0.032±0.003abc	1.275±0.012a
	3	29.53±0.19e	5.92±0.15abc	0.167±0.033c	0.063±0.006c	0.027±0.006ab	1.793±0.088bc
	4	29.40±0.21e	6.57±0.09bcd	0.117±0.009c	0.058±0.003c	0.025±0.002a	2.106±0.002e
	5	28.77±0.29bcde	6.75±0.09d	0.123±0.015c	0.060±0.004c	0.032±0.003abc	1.138±0.058a
Batch C	1	27.73±0.47ab	6.61±0.17cd	0.019±0.015a	0.002±0.000a	0.022±0.006a	1.240±0.058a
	2	27.97±0.20abc	6.31±0.07abcd	0.016±0.004a	0.002±0.000a	0.028±0.000abc	1.253±0.020a
	3	27.60±0.17a	6.07±0.19abcd	0.004±0.000a	0.003±0.000a	0.033±0.002abc	1.660±0.058b
	4	27.60±0.12a	6.68±0.21d	0.004±0.000a	0.002±0.000a	0.045±0.004c	1.095±0.004a
	5	28.87±0.15cde	5.95±0.09abc	0.003±0.000a	0.002±0.000a	0.028±0.001abc	1.976±0.006cde

Same alphabets along the column is not significant difference (P>0.05) according to Tukey HSD statistics; Mean ± Standard error, (n=3)

The variation in the bioaccumulation level could be due to the fact that plants have more than one method of tolerating high metals within one plant species, which includes limiting metal transport in plants through the internal tolerance mechanism and self protection from stress [16]. Gardea-Torresdey et al. [43] cited in Akpor and Muchie [44] reported that plants could protect themselves by detoxification through the production of phytochelatins (cadmium), superoxide dismutase an enzyme which increases when plants sense an enhancement of lead in its tissue (lead). The level of cadmium and lead of the *Eichhornia crassipes* relative to the pH and the heavy metals (cadmium and lead) of the water is low. This suggests that the *Eichhornia crassipes* could be aiding in the detoxification of the pollutants deposited into the aquatic ecosystem rich in cadmium and lead.

4. Conclusion

Eichhornia crassipes is a non-native, exotic, foreign species to Nigerian waterways especially in the Niger Delta. *Eichhornia crassipes* is often regarded as one of the most dangerous macrophytes, which causes several problems in the environment; hence it's often referred to as worst aquatic plant. This study assessed cadmium and lead concentration in the *Eichhornia crassipes* the river nun with regard to the water quality concentrations. The study found out that the concentration of lead in *Eichhornia crassipes* is higher than that of the water quality. Also apart from Batch B, the concentration of cadmium followed similar trend with lead. This suggests that the *Eichhornia crassipes* is contributing to the remediation of the heavy metals (cadmium and lead) from River Nun at Amassoma axis.

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